Discovery of nests and an egg of Loria's Bird of Paradise *Cnemophilus (Loria) loriae* (Paradisaeidae)

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Introduction

Loria's Bird of Paradise *Cnemophilus (Loria) loriae* is a small (22 cm, 80–100 g) and stocky sexually dimorphic fruit-eating bird of paradise (Paradisaeidae) discovered in 1893. It lives in mid-montane wet forests of the central mountain ranges of New Guinea from the Weyland Mountains of Irian Jaya eastward to the southern Owen Stanley Range of Papua New Guinea, at 1200–3000, mostly 1800–2400, m asl (Cooper & Forshaw 1977, Beehler *et al.* 1986, Coates 1990).

Adult males are glossy velvety-black with iridescent blue-green lores and forehead, a slight purple gloss on upperparts and iridescent blue-green or violet-purple sheens on the inner secondaries. The bill is black, and the obvious fleshy gape and inside mouth are cream yellow, white or pale green. Adult females are uniform yellowish-olive or dull greenish-olive (Coates 1990). Immature males have the plumage of adult females, and a distinct grey juvenile plumage is known (Frith 1987).

Little else has been learnt about this taxonomically interesting bird of paradise, one of three species constituting the distinct subfamily Cnemophilinae. Bock (1963) showed Loria's Bird to be most closely related to the other monotypic cnemophilines, the Crested Bird of Paradise *Cnemophilus macgregorii* (hereafter Crested Bird), and the Yellow-breasted Bird of Paradise *Loboparadisea sericea*. Clench (1992) concluded that Macgregor's Bird of Paradise *Macgregoria pulchra*, presently placed in Paradisaeinae (Gilliard 1969, Cooper & Forshaw 1977), should be in the Cnemophilinae.

Diamond (1972) suggested that *Loria* be merged with *Cnemophilus* and Schodde (1976) suggested that *Loboparadisaea* might also be merged with *Cnemophilus*. Some subsequent authors have placed only *Loria* into *Cnemophilus* (Beehler & Finch 1985, Beehler *et al.* 1986), while Frith (1987) and Frith & Harrison (1989) considered this reasonable but preferred to retain *Loria* until kowledge of living birds was available. Frith (1987) stressed the need for knowledge of nidification in Loria's Bird of Paradise (hereafter Loria's Bird) to further understand relationships within the Cnemophilinae, and Paradisaeidae as a whole.

Loria's Bird is assumed to be polygynous, as solitary adult males are known to attend conspicuous forest canopy calling-perches and to advertise their location with regularly repeated, ventriloquial bell-like notes (Gilliard 1969, Coates 1990). Lone individuals and aggregations of up to ten female-plumaged birds have been recorded feeding upon

fruits (thought to be the exclusive diet) of several plant species from the ground to the forest canopy, but mostly low in the forest (Cooper & Forshaw 1977, Coates 1990). Majnep (in Majnep & Bulmer 1977) suggested that both female and male attend a domed nest when nestlings are present, but no nest or egg has been formally described. The only indication of breeding in the species is Ripley's (1964) record of two "juveniles, one unsexed, not long out of the nest" in the Ilaga Valley in the Snow Mountains of Irian Jaya in September.

Discovery of the nests

Having discovered a number of nests and eggs of several bird of paradise species in the Tari Gap and Ambua Lodge areas of the Southern Highlands of Papua New Guinea (Frith & Frith 1990, 1992a, 1993b,c) we returned to Ambua Lodge for the period 15 December–27 January 1993 specifically to attempt to find a nest of Loria's Bird, which is not uncommon there (Frith & Frith 1992b, 1993a). Several domed nests of the congeneric Crested Bird found within several metres of the ground (Frith & Frith 1993c) led us to anticipate a domed nest built close to the ground by Loria's Bird. In the event we found six nests.

Nest 1

Joseph Thavo, naturalist at Ambua Lodge, told us of seeing a female-plumaged Loria's Bird carrying nest-material on a number of occasions over a period of a week or more some six to eight weeks previously. We visited the location with Thavo on 17 December and there flushed a female-plumaged Loria's Bird from near the ground, and subsequently found a used nest (nest 1) built upon a near-vertical exposed rock face (Plate 1). The nest site was in mature mossy forest *c.* 50 m from and 15 m above a 15 m wide boulder-strewn swift-flowing mountain torrent, on a 45° slope falling to the SSE. A small rock overhang directly above the nest protected the site and kept the nest dry. The face of exposed rock extended some 2 m vertically above the nest site.

Within this nest were numerous egg fragments, the largest measuring 13.8 × 12.0 mm, indicating an egg of pinkish-buff ground colour with numerous brown, russet and purplish-grey spots and blotches over most of the surface but conspicuously more dense on the larger end. The egg had only slight gloss and no broad longitudinal blotches or streakings as are typical of eggs of most members of the Paradisaeinae.

The nest was roughly globular, but vertically flattish and sparse at the back where hard against the rock, with a horizontally-ovate entrance hole in the front. The external structure was a substantial accumulation of green mosses heavily 'decorated' or 'camouflaged' on the front half of the top and around the sides, down to the mid-entrance-hole level, with 40 (now dried and shrivelled) filmy fern fronds (*Hymenophyllum* spp.) most numerous directly above, and overhanging, the entrance. Incorporated into the moss of the entrance perch and below it were *c.* 30 sticks up to 235 mm long and 4.5 (mostly

TABLE 1
Direction entrance faced (in compass degrees), height and measurements (mm), as indicated in Figure 1, of five Loria's Bird of Paradise nests; with means for five Crested Birds' nests

Nest no.	Nest entrance faced	Height above ground	a	b	c	d	e	f	g	h	i	j
1	140	600	275	250	130	110	90	110	155	130	100	30
2	210	2100	280	265	—	112	65	178	190	110	—	24
3	20	1650	230	200	126	95	76	98	212	122	110	41
4	40	2000	220	220	—	85	70	70	175	112	—	27
5	315	1500	193	—	—	105	85	94	160	122	—	23
Means												
Loria's	145	1580	240	234	128	101	77	110	178	119	105	29
Crested	—	2609	207	197	107	122	74	—	175	126	123	45

2–3) mm in diameter, a part of some being visible. Two live epiphytic orchid stems were incorporated into the moss beneath the entrance perch (Plates 1 and 2).

The inner nest-chamber lining consisted of a discrete frail 'basket' of pale, supple, fine (<1 mm diameter) epiphytic orchid stems, and a few fine vine tendrils up to 400 mm long (Plate 2). Many of the longer orchid stems of this inner 'basket' encircled the entire inside or outside of its globular shape. The base of the 'basket' was thicker and denser, many of the orchid stems lining the egg-cup being shorter in length than elsewhere. There was no egg-cup lining material different to the rest of the lining. No tree leaves or 'comb-tooth' fern fronds were used in this nest, measurements of which appear in Table 1 and are indicated in Figure 1.

Nest 2

Following the finding of nest 1 all saplings, trees and rock faces in an immediate area of 2 km^2 at altitudes of *c.* 2150 to 2200 m were searched for nests. On 18 December recently used nest 2, with a female-plumaged Loria's Bird scolding close by, was found in similar habitat and some 500 m downstream on the same torrent (Fig. 2). This nest was built upon the side of a moss-covered, 40 cm diameter, tree trunk and was extremely cryptic (Plate 2). The nest tree was 55 m from and 18 m above the torrent on a *c.* 40° slope falling to the W. To confirm the status of this nest a fresh leaf was placed within its egg cup, which remained there until 6 January when the nest was collected and measured (Table 1). Nest materials were similar to those of nest 1, but there was a much more substantial moss base and *c.* 110 sticks up to 280 mm long and 3 (a few to 4.5) mm in diameter beneath the entrance perch. This base could have included material from a previous nest, but it may have been required to provide purchase on the vertical tree

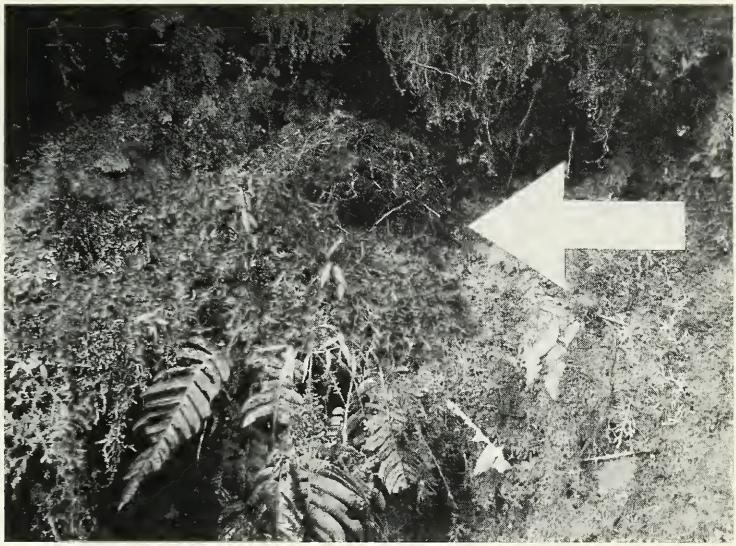

Plate 1. Nest of Loria's Bird of Paradise. Upper, nest 1 *in situ*, the arrow to the right of the nest pointing to the entrance perch level below the entrance aperture. Lower, nest 1 detail.

Plate 2 (overleaf). Nests of Loria's Bird of Paradise. Upper, the chamber lining 'basket' removed from nest 1. Lower, nest 2 *in situ* on tree trunk, the index finger-tip of M. Media's left hand being at the entrance aperture.

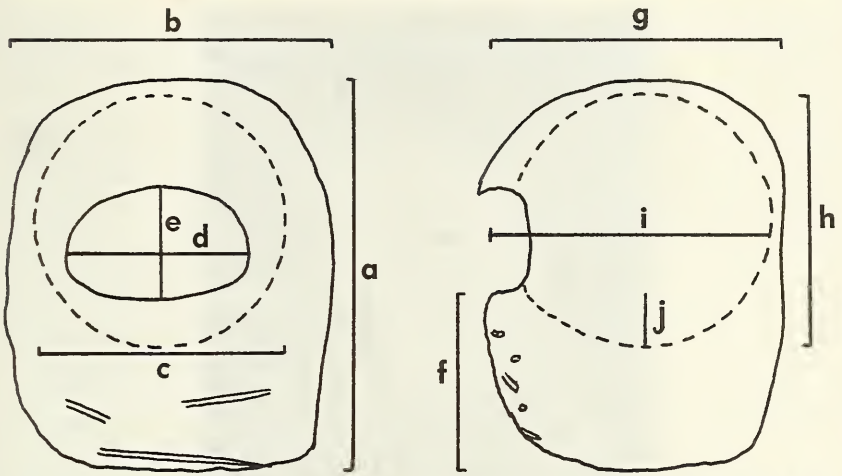

Figure 1. Schematic front (left) and side (right) profile of a Loria's Bird of Paradise domed nest to show parameters measured, and presented in Table 1: a=nest height; b=nest width; c=nest chamber width; d=entrance aperture width, and e=its depth; f=height to entrance perch; g=nest depth; h=nest chamber height, and i=its depth; j=egg-cup depth from entrance perch level.

trunk, there being no epiphytic plants or other structures to support it. Unlike nest 1, the nest base had a few tree leaves and leaf pieces incorporated into it. The entire inner nest-lining 'basket' consisted of the supple straw-coloured stems of epiphytic orchids up to 550 mm long and 1.5 mm in diameter, with a few black tendril-like rootlets or stems up to 760 mm long.

Nest 3

This nest was found on 21 December under construction, being built of moss and filmy fern fronds, but lacking a chamber lining of orchid stems. A silent female-plumaged Loria's Bird watched us at this nest. The nest was *c.* 200 m from nest 1 on a bearing of 130°, on the opposite side of the same stream (Fig. 2) in mature moss forest on a 45–50° slope falling to the NNE. This nest was extremely cryptic *in situ*, its materials perfectly matching living plants growing on immediately adjacent rock faces. When complete, nest materials were similar to nest 1 but the external appearance was dominated by fresh deep-green and blue-green filmy fern fronds (*Hymenophyllum* spp.) rather than by moss. Several fern fronds were placed below the entrance perch. Some 33 straight sticks, up to 305 mm long and 5.5 mm in diameter, were in part or entirely visible on and in the front of the nest below the entrance perch. The inner nest-lining was predominantly of supple straw-coloured orchid stems, with several other fine woody tendrils, up to 600 mm long and 1.8 mm in diameter. The base of the nest was a most substantial accumulation of filmy ferns laid atop one another to form a dense and

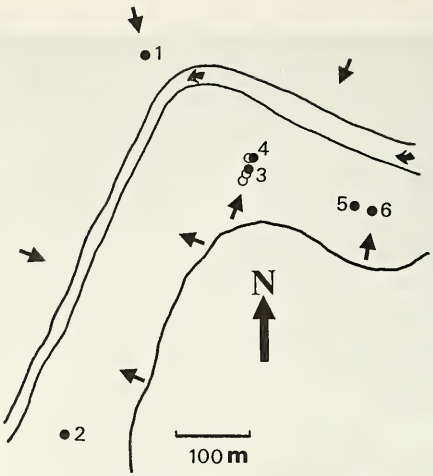

Figure 2. Schematic map of Loria's Bird of Paradise nest locations, to scale. Numbered solid circles are nests examined and open circles are older, disused, nests. Parallel lines indicate a mountain torrent, flowing from top to bottom as arrowed. Single contour line shows ridge top, and arrows indicate steep fall of forested terrain toward torrent.

compacted wad intersected by the sticks. No comb-tooth fern fronds were present.

On 22, 24, 28, 29, 30 December 1992 and at 1130 hrs on 1 January 1993 a female-plumaged Loria's Bird was seen adding materials to the nest, which was empty. At 1420 h on 2 January the bird was flushed from a fresh elliptical ovate egg measuring 36.8 × 24.5 mm and weighing 11.3 g. This slightly-glossed egg was pale pink-buff sparsely spotted and blotched all over with russet, rufous, tan-browns and purple-greys. These markings, and fine short scribblings, were more dense in a band close to and about the larger end (Fig. 3).

The nest was inspected once a day until 23 January and on each occasion a female-plumaged bird was flushed or was in the immediate nest area showing concern. It was heard to give only a soft, low rasping scold note repeated 4–5 times. At 1430 hrs on the 24th the egg showed no sign of pipping. At 0900 hrs on the 25th the bird flushed off the egg, now 10.5 g and with one small shell eruption at its larger end. At 1700 hrs on the 26th the bird again flushed off the pipping egg, and at 0730 on the 27th off a naked hatchling. Thus the egg hatched on the 26th day after laying, assuming it was laid sometime before 1430 hrs on 2 January. The hatchling was mid blue-grey dorsally and on its legs, eyes and forecrown; the ventral body, crown and nape were paler and a yellowish-fawn, the bill brownish-grey with a tiny white egg-tooth, the gape white, and claws conspicuously white. The nestling was found dead and cold with head wounds late the next day; it was preserved in alcohol and subsequently deposited in the Papua New Guinea National Museum collection in Port Moresby.

Figure 3. Egg and egg fragment of Loria's Bird of Paradise. Upper, freshly laid egg of nest 3; lower, egg fragment of nest 5.

When collected for examination, nest 3 was found to be built directly upon an older nest structure, with yet another old nest immediately behind and above it on the same rock (Fig. 2).

Nest 4

This nest was found on 21 December, 10 m directly downslope from nest 3. Clearly a nest of the previous season, it was extremely cryptic *in situ*. It was built atop a plant-covered rocky protuberance at the top of an exposed rock face lacking protective rock directly above. The nest

was built of similar materials to the previous ones, having some 30 sticks incorporated into the base, including a couple of large orchid stems up to 450 mm long and 5 (mostly 3–4) mm in diameter. One 'stick' was a 290 mm length of heavily-hooked *Calamus* palm stem. Also within the basal stick and moss material were several dead, dry *Nastus* bamboo leaves. Filmy fern fronds used to 'decorate' or 'camouflage' the nest exterior consisted of at least four species. A tooth-comb-like fern frond, possibly *Doodia* or a related genus, was placed above the entrance hole and three more were incorporated into the upper nest material but were not visible externally. Only 30 cm from and above this nest on the same rock, were the remains of an older nest, too deteriorated to be measured.

Nest 5

On 22 December nest 5 was found, *c.* 150 m upstream from nest 3 on the same stream bank. This nest was built upon a rock face, with rock directly above protruding over the nest just far enough to protect it from rain. Rocks immediately about this nest were lushly vegetated with mosses and filmy ferns so similar to the external nest materials that the structure was almost impossible to discern, even with knowledge of its location. This nest was 45 m above the stream and *c.* 65 m from its bank, on a well moss-forested wet rocky north-facing 55° slope that fell from the ridge top some 40 m above the nest site all the way to the stream. The whole area, of this and all the other nests between the ridge-top and the torrent (Fig. 2), was so steep, wet and unstable that it would be rarely traversed by people.

The nest contained a holed egg fragment measuring 29 × 23 mm (Fig. 3) and seven smaller ones, up to 9 × 7 mm, of a pink-buff ground colour spotted and blotched with numerous markings of browns, tans and purplish-greys, most densely on the broad end. The fragments lacked gloss, possibly due to weathering as nest 5 was at least one year old.

The nest contained only a couple of sticks within and beneath its base, up to 142 mm long and 3 mm in diameter. It was generally of similar materials to the others. Numerous filmy fern fronds were atop the structure, hanging over the entrance hole, and a few also on the upper sides. Conspicuously placed atop the nest were several 'comb-tooth' fern fronds and more of these were found beneath the moss of the upper structure. There was a substantial number of filmy fern fronds above the base moss material, with a couple of 'comb-tooth' fern fronds (*Ctenopteris* sp.) directly beneath the egg-cup lining of supple epiphytic orchid stems. The latter were up to 450 mm long and 0.5–1.5 (mostly 1) mm in diameter, plus a few fine supple black root tendrils. The lining of the central egg cup was of orchid stem lengths of only 100–150 mm.

Nest 6

This, probably a recently used nest of the season, was *c.* 25 m from nest 5 on the same level of the same slope, in a similar site on a moss and filmy fern-covered rock face directly beneath a small projecting

rock-ledge overhang. The nest was so well integrated into the rock face and vegetation that it could not be removed without its destruction. It was 1.2 m above ground and the entrance faced N.

Statistical summary of nests

The height above ground, direction the nest entrance faced, and measurements of nests 1–5 are summarised in Table 1, the measurements taken being indicated in Figure 1.

Discussion

Although Loria's Bird is approximately 10% smaller than the Crested Bird, the external dimensions of its nest (Fig. 1a,b,c,g) were larger; its nest entrance aperture and other internal dimensions were smaller or similar (Fig. 1d,e,h,i,j); see Table 1. Whilst the Crested Bird is known to build a nest on a tree stump, trunk or branches (Frith & Frith 1993c), it would appear that, in the area studied, Loria's Bird specializes in nesting on lushly-vegetated near-vertical rock faces on steep slopes of deeply dissected mountain torrent valleys, notwithstanding one nest on a tree trunk. Six Loria's Bird nests were at a mean of 1.5 m above ground, 1 m lower than five Crested Bird nests (Frith & Frith 1993c).

Loria's nest is almost identical in shape, construction and materials to that of the congeneric Crested Bird except that the egg-cup is not lined with distinctly finer orchid stems (Frith & Frith 1993c) but with shorter lengths of the same orchid stems that constitute the entire inner nest lining (Plate 2). Nine Loria's and five Crested Bird nests suggest that the former tends to use more filmy fern and the latter more 'comb-tooth' fronds, whilst both utilize much moss, orchid stems and sticks. Samples are, however, small and from a single area for each species.

The nest of Loria's Bird, and that of the Crested Bird, is unlike all other known bird of paradise nests in being a globular domed structure incorporating woody sticks as a foundation (Gilliard 1969, Cooper & Forshaw 1977, Coats 1990, Frith & Frith 1990a, 1992a, 1993b,c). Sticks in the Loria's Bird nests we studied were all within the moss and ferns beneath the entrance perch, none being fully exposed beneath this as in the Crested Bird's nest.

The use of nest 'foundation' sticks by both *Cnemophilus* species is particularly noteworthy. All other bird of paradise nests known (26 paradisaeine species) are open shallow cups of orchid and/or vine stems or tendrils with or without some moss, fern fronds or leaves (Gilliard 1969, Cooper & Forshaw 1977, Coates 1990, Frith 1991, Frith & Frith 1990a, 1992a, 1993b,c); twigs or sticks have not been convincingly documented as used by most species.

The Crested Bird egg fragments described by Frith & Frith (1993c) indicate an egg of similar colour and markings to that of Loria's Bird. The hatchling of Loria's Bird is naked and predominantly dark-skinned, as is characteristic of the Crested Bird and all other birds of paradise, in contrast to pale-skinned, conspicuously downy, bowerbird

hatchlings (Ptilonorhynchidae), as discussed elsewhere (Frith & Frith 1990b, 1993b,c, 1994). Studies of successfully nesting Loria's Birds are required to clarify if its grey plumage (Frith 1987) is in fact a briefly-worn juvenile plumage common to all populations of the species, notwithstanding Ripley's (1964) report of two "juveniles" in typical adult female plumage. We take this opportunity to document that the bird photographed by Peckover (1990: 6, plate 5) and claimed to be a Loria's Bird in immature male plumage is in fact a female-plumaged Yellow-breasted Bird of Paradise.

Our numerous nest visits during the entire incubation period at nest 3 always involved disturbing a female-plumaged Loria's Bird, which we assume to have been a single female. We doubt that male Loria's Birds visit the nest (Majnep, in Majnep & Bulmer 1977), and consider it probable that females are uniparental at the nest and feed young exclusively fruit, as in the Crested Bird (Frith & Frith 1993c).

The incubation period at nest 3 was 25 days ($\pm$ 1 day), longer than the 16–22 days recorded for other, lowland nesting, birds of paradise (Coates 1990, Worth *et al.* 1991, Frith 1985, 1991) and most passerines (Skutch 1976). This long incubation is probably largely due to its nesting in the cold wet climate of a relatively high altitude (Skutch 1976), as found in other passerines of the area (Frith & Frith 1990b, 1994). The fresh egg weight of 11.3 g represents 12.1% of mean adult female weight (93.3, $n=3$; Diamond 1972) or 12.2% of mean adult weight (92.4, $n=6$; Frith & Frith 1993a).

Figure 2 shows that nest 3 had two old nests immediately adjacent and two more (including nest 4) 10 m away. Nest 5 was 25 m from nest 6. We consider it probable that these represent examples of 'traditional' nesting by female Loria's Birds using the same nest site or immediate area over subsequent seasons, one bird building all nests associated with nest 3 and another both 5 and 6. Such 'traditional' nesting by polygynous birds of paradise and other passerines has been reported and discussed elsewhere (Frith & Frith 1992a, 1993b, 1994).

The finding of a grey juvenile plumage in both Loria's and Crested Birds, together with new information presented here, strongly supports the incorporation of *Loria loriae* into *Cnemophilus* (Diamond 1972, Beehler & Finch 1985, Beehler *et al.* 1986) and the resultant synonomy of *Loria*. Knowledge of living, or the genetics of, monotypic cnemophiline *Loboparadisea sericea* is now eagerly awaited in order to properly assess the validity of *Loboparadisea*.

Diamond (1972) found no altitudinal overlap between Loria's Bird and the Crested Bird. Cooper (in Cooper & Forshaw 1977) found both sympatric, however, and we have recorded both species in forests of the Ambua Lodge to Tari Gap road at altitudes of 2200 to 2650 m (Frith & Frith 1992b, 1993a) but saw no nesting by Loria's Bird at the higher elevations. Diamond (1986) pointed out that numerous inter- and intrageneric hybrids are produced by bird of paradise species in which males are known or suspected to be promiscuous. That none are known to involve the cnemophilines led him to ask if they are monogamous birds. Our observations strongly suggest that female Loria's and the Crested Birds are uniparental nesters, and that males are probably